APPLICATION NO. 10/772,597
INVENTION: Decisioning rules for turbo and convolutional decoding
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CLAIMS

WHAT IS CLAIMED IS:

Claim **1.** (currently amended) A method for performing a new turbo decoding algorithm using a-posteriori probability $p(s,s'|y)$ in equations **(13)** for defining the maximum a-posteriori probability MAP, comprising:

using a new statistical definition of the MAP logarithm likelihood ratio $L(d(k)|y)$ in equations **(18)**

$$L(d(k))|y) = \ln[\ \Sigma_{(s,s'|d(k)=+1)}\ p(s,s'|y)] \\ -\ln[\ \Sigma_{(s,s'|d(k)=-1)}\ p(s,s'|y)\ ]$$

equal to the natural logarithm of the ratio of the a-posteriori probability $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=1$ to the $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=0$,

using a factorization of the a-posteriori probability $p(s,s'|y)$ in equations (13) into the product of the a-posteriori probabilities

$$p(s,s'|y)=p(s|s',y(k))p(s|y(j>k))p(s'|y(j<k)),$$

using a turbo decoding forward recursion equation

$$p(s|y(j<k),y(k)) = \Sigma_{\text{all } s'}\ p(s|s',y(k))\ p(s'|y(j<k))$$

for evaluating said a-posteriori probability $p(s'|y(j<k))$ in equations (14) using $p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at $k-1$ and given the observed symbol $y(k)$ to update these recursions for the assumed value of the user data bits $d(k)$ equivalent to the transmitted symbol $x(k)$ which is the modulated symbol corresponding to $d(k)$,

using a turbo decoding backward recursion equation

$$p(s'|y(j>k-1) = \Sigma_{\text{all } s}\, p(s|y(j>k))p(s'|s,y(k))$$

for evaluating the a-posteriori probability $p(s|y(j>k))$ in equations (15) using said $p(s'|s,y(k)) = p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s \rightarrow s'$ to the new state s' at $k-1$ from the previous state s at k and given said observed symbol $y(k)$ to update these recursions for said assumed value of $d(k)$,

evaluating the natural logarithm of the state transition posteriori probability $p(s|s',y(k))=p(s'|s,y(k))$ equal to a new decisioning metric DX in equations (11),(16), defined by equation

$$\begin{aligned} \ln[p(s|s',y(k)) &= \ln[p(s'|s,y(k))] \\ &= \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k)) \\ &= DX \end{aligned}$$

wherein $\underline{p}$ is the natural logarithm ln of p, x^* is the complex conjugate of x, and ln[o] is the natural logarithm of [o],

whereby said new state transition probabilities in said MAP equations use said DX linear in $y(k)$ in place of the current use of the maximum likelihood decisioning metric

$DM = [\ -|y(k) - x(k)|^2/2\sigma^2\ ]$ which is a quadratic function of $y(k)$,

whereby said MAP turbo decoding algorithms provide some of the performance improvements demonstrated in FIG. **5,6** using said DX, and

whereby this new a-posteriori mathematical framework enables said MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of said DX linear in said $y(k)$.

Claim **2.** (currently amended) A method for performing a new convolutional decoding algorithm using the MAP a-posteriori probability $p(s,s'|y)$ in equations (13), comprising::

using a new maximum a-posteriori principle which maximizes the a-posteriori probability $p(x|y)$ of the transmitted symbol x given the received symbol y to replace the current maximum likelihood principle which maximizes the likelihood probability $p(y|x)$ of y given x for deriving the forward and the backward recursive equations to implement convolutional decoding,

using the factorization of the a-posteriori probability $p(s,s'|y)$ in equations (13) into the product of said a-posteriori probabilities $p(s'|y(j<k))$, $p(s|s',y(k))$, $p(s|y(j>k))$ to identify the convolutional decoding forward state metric $a_{k-1}(s')$, backward state metric $b_k(s)$, and state transition metric $p_k(s|s')$ as the a-posteriori probability factors

$$
\begin{aligned}
p_k(s|s') &= p(s|s',y(k)) \\
b_k(s) &= p(s|y(j>k)) \\
a_{k-1}(s') &= p(s'|y(j<k)),
\end{aligned}
$$

using a convolutional decoding forward recursion equation in

equations (14) for evaluating said a-posteriori probability $a_k(s)=p(s|y(j<k),y(k))$ using said $p_k(s|s')=p(s|s',y(k))$ as said state transition probability of the trellis transition path $s'\rightarrow s$ to the new state s at k from the previous state s' at k-1,

using a convolutional decoding backward recursion equation in equations (15) for evaluating said a-posteriori probability $b_k(s)=p(s|y(j>k))$ using said $p_k(s'|s)=p(s'|s,y(k))$ as said state transition probability of the trellis transition path $s\rightarrow s'$ to the new state s' at k-1 from the previous state s at k,

evaluating the natural logarithm of said state transition a-posteriori probabilities

$$\begin{aligned}\ln[p_k(s'|s)] &= \ln[p(s'|s,y(k))]\\ &= \ln[p(s|s',y(k))]\\ &= \ln[p_k(s|s')]\\ &= DX\end{aligned}$$

equal to a new decisioning metric DX in equations (16), and

implementing said convolutional decoding algorithms to obtain some of the performance improvements demonstrated in FIG. **5**,**6** using said DX.

Claim **3**. (currently amended) Wherein in claim **2** a method for implementing the new convolutional decoding recursive equations, said method comprising:

implementing in equations (14) a forward recursion equation for evaluating the natural logarithm, $\underline{a}_k$, of a_k using the natural logarithm of the state transition a-posteriori probability $\underline{p}_k=\ln[p(s|s',y(k))]$ of the trellis transition

path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1, which is equation

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + \underline{p}_k(s|s')]$$

$$= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')]$$

$$= \max_{s'} [\underline{a}_{k-1}(s') + \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]$$

wherein said $DX(s|s') = \underline{p}_k(s|s')] = \underline{p}_k(s'|s) = DX(s'|s) = DX$ is a new decisioning metric, and

implementing in equations (15) a backward recursion equation for evaluating the natural logarithm, $\underline{b}_k$. of b_k using the natural logarithm of said state transition a-posteriori probability $\underline{p}_k = \ln[p(s'|s,y(k))] = \ln[p(s|s',y(k))]$ of the trellis transition path $s \rightarrow s'$ to the new state s' at k-1 and is equation

$$\underline{b}_{k-1}(s') = \max_{s} [\underline{b}_k(s) + DX(s'|s)].$$